Report on the Testing of the

Waters Corporation
Alliance iS Column Heater Cooler, (CHC)

In accordance with:
FCC Part 15 Subpart C §15.225
ISED RSS-210 Issue 10, December 2019

Prepared for: Waters Corporation
34 Maple Street
Milford, Massachusets, 01757 USA

America

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FCC Accreditation Designation Number US1233
FCC Test Site Registration Number 967699
Innovation, Science, and Economic Development Canada Lab Code 23932

EXECUTIVE SUMMARY

A sample of this product was tested and found to be compliant with the standards listed above.

A2LA Cert. No. 2955.09

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1 Report Summary

1.1 Report Modification Record

Alterations and additions to this report will be issued to the holders of each copy in the form of a complete document.

Table 1.1-1 – Modification Record

Issue	Description of Change	Date of Issue
0	First Issue	4/4/2023

1.2 Introduction

The purpose of this report is to demonstrate compliance with Part 15 Subpart C of the FCC's Code of Federal Regulations Section 15.225 and Innovation Science and Economic Development Canada's Radio Standards Specification RSS-210 for the tests documented herein.

Applicant	Mr. Glen Randy Weaner
Manufacturer	Waters Corporation
Applicant's Email Address	randy_weaner@waters.com
Model Name	Alliance iS Column Heater Cooler, (CHC)
Model Number(s):	279004951
Serial Number	N/A
FCC ID	2A93G-CHC-PHC-001
ISED Certification Number	29985-CHC-PHC-001
Hardware Version(s)	Revision B
Software Version(s)	USAMIL-R90XVYLGusbtil
Number of Samples Tested	1
Test Specification/Issue/Date	US Code of Federal REgulation (CFR): Title 47, Part 15, Subpart C: §15.225 - Operation within the band 13.110 - 14.010 MHz, 2022 ISED Canada Radio Standards Specification: RSS-210 - Licence-Exempt Radio Apparatus: Category I Equipment Issue 10 December 2019
Order Number	72183357
Date of Receipt of EUT	11/14/2022
Start of Test	12/7/2022
Finish of Test	1/18/2023

Related Document(s)	ANSI C63.10-2013: American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Device. US Code of Federal Regulations (CFR): Title 47, Part 2, Subpart J: Equipment Authorization Procedures, 2022. ISED Canada Radio Standards Specification: RSS-GEN – General Requirements for Compliance of Radio Apparatus, Issue 5, Amendment 1 (March 2019), Amendment 2 (February 2021)

1.3 Brief Summary of Results

A brief summary of the tests carried out in accordance with FCC Part 15.225 and ISED Canada's RSS-210 is shown below.

Table 1.3-1: Test Result Summary

Test Parameter	Test Plan (Yes/No)	Test Result	FCC 47 CFR Rule Part	ISED Canada's RSS	Test Report Page No
Antenna Requirement	Yes	Pass	15.203, 15.204	-------	10
20 dB Bandwidth	Yes	Pass	15.215(c)	-------	18
Frequency Stability	Yes	Pass	15.225(e)	RSS-210 B.6(b)	16
Occupied bandwidth	Yes	Pass	-	RSS-Gen 6.7	19
Emission Mask	Yes	Pass	15.225(a)(b)(c)	RSS-210 B.6(a)(i)(ii)(iii)	22
Radiated Spurious Emissions	Yes	Pass	15.209, 15.225(d)	RSS-210 B.6(a)(iv)	24
AC Power Line Conducted Emissions	Yes	Pass	15.207(a)	RSS-GEN 8.8	11

1.4 Product Information

1.4.1 Technical Description

The Column Heater Cooler, (CHC) is an AC powered device to house the fluidic column used to perform HPLC, (High Pressure Liquid Chromatography) separations for the Alliance IS system. The CHC assembly can provide temperature to the column from 4 to 90 ºC. If the LC column is equipped with a passive NFC tag, (13.56MHz), it will be read when the front door of the CHC is closed. The antenna circuitry is normally not active until the door closure service event. Changing columns is typical performed by the operator from every couple of hours to once a week or longer depending on the application and service needs. Data from the tag is stored in the system.

Table 1.4.1-1 – Wireless Technical Information

Detail	Description
FCC ID	2A93G-CHC-PHC-001
ISED Certification Number	29985-CHC-PHC-001
Model Name	Alliance iS Column Heater Cooler, (CHC)
Model Number(s)	279004951
Frequency Range (MHz)	13.56 MHz
Operating voltage	100 – 240 VAC
Antenna Type / Gain:	PCB Antenna

A full description and detailed product specification details are available from the manufacturer.

Figure 1.4.1-1 – Front View of the EUT

Figure 1.4.1-2 – Back View of the EUT

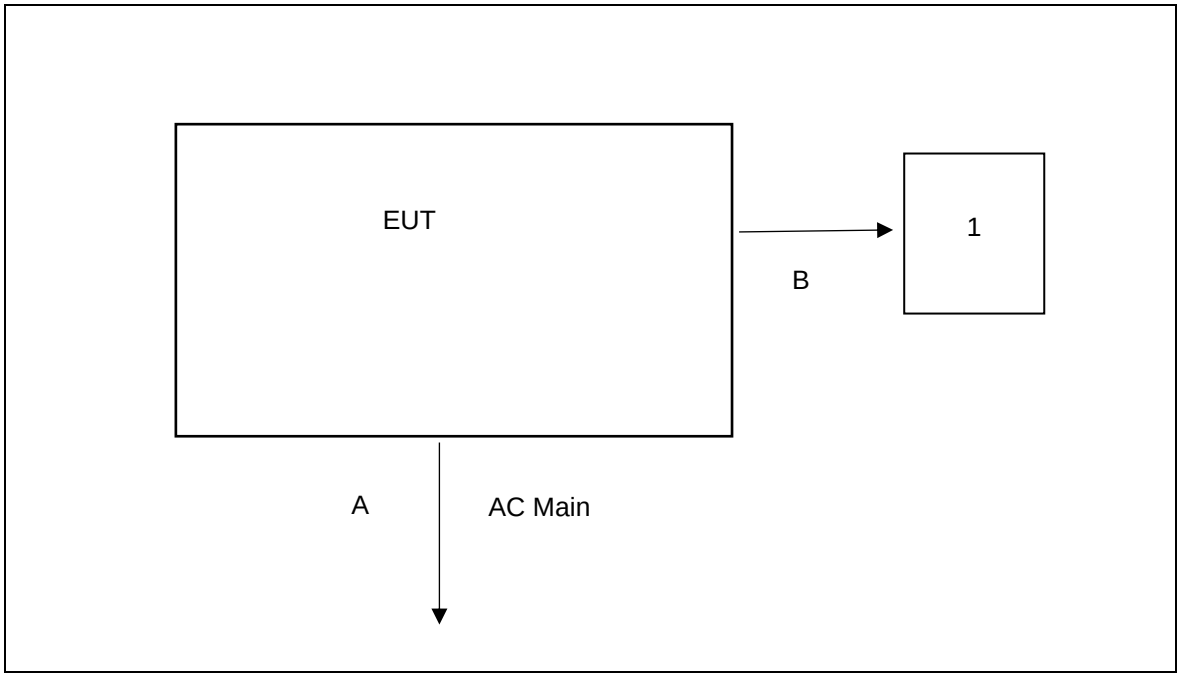

Figure 1.4.1-3 – Test Setup Block Diagram

Table 1.4.1-2 – Support Equipment Descriptions

Item	Make/Model	Description
1	DELL	Laptop for configuration

Table 1.4.1-3: Cable Description

Item	Cable Type	Description
A	Power supply	AC Main power cable, 1m
B	N/A	USB to serial to 3 pin socket connection Programming cable

1.4.2 Modes of Operation

The tested mode of operation was: The EUT was AC Powered and was transmitting continuous RFID 13.56MHz.

1.4.3 Monitoring of Performance

For radiated emissions, the EUT was evaluated in worst case orientations. See test setup photos for more information. The EUT was programmed to generate a continuously modulated signal on each channel evaluated.

1.5 Deviations from the Standard

No deviations from the applicable test standard were made during testing.

1.6 EUT Modification Record

The table below details modifications made to the EUT during the test program. The modifications incorporated during each test are recorded on the appropriate test pages.

Modification State	Description of Modification still fitted to EUT	Modification Fitted By	Date Modification Fitted
0	Initial State		
1	Added 0431173771 Fair rite with 2 loops and removed Schaffner FN9222-15-06 inlet filter.	TUV SUD America, Alpharetta, GA	1/10/2023

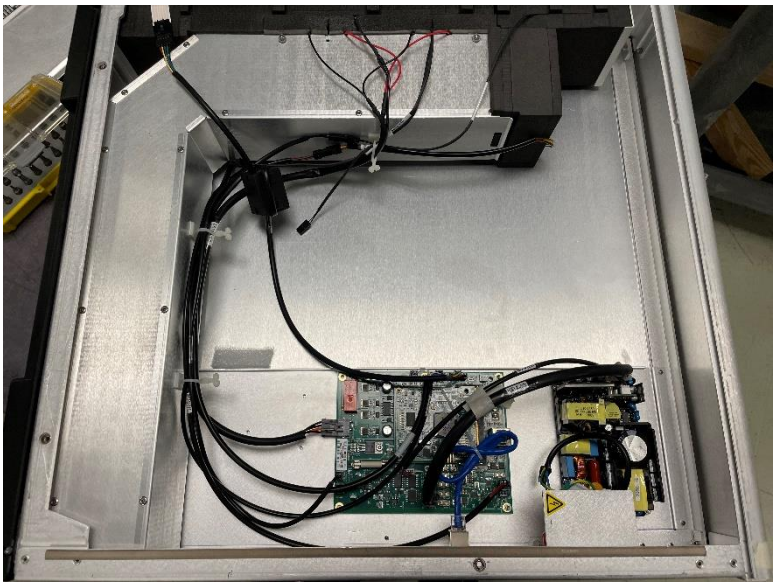

Figure 1.6-1 – Added 0431173551 Fair rite with 2 loops

Figure 1.6-2 – Removed Schaffner FN9222-15-06 inlet filter

1.7 Test Location

TÜV SÜD conducted the following tests at our Alpharetta, GA test laboratory.

Test Name	Name of Engineer(s)	Accreditation
Antenna Requirement	Bhagyashree Chaudhary	A2LA
20 dB/ 99% Bandwidth	Divya Adusumilli	A2LA
Frequency Tolerance	Bhagyashree Chaudhary	A2LA
Occupied bandwidth	Divya Adusumilli	A2LA
Emission Mask	Bhagyashree Chaudhary	A2LA
Spurious Radiated Emissions	Bhagyashree Chaudhary	A2LA
AC Power Line Conducted Emissions	Divya Adusumilli	A2LA

Office address:
TÜV SÜD America
5945 Cabot Parkway, Suite 100
Alpharetta, GA 30005, USA

2 Test Details

2.1 Antenna Requirement

2.1.1 Specification Reference

FCC Section: 15.203, 15.204

2.1.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state “1”, as noted in §1.6.

2.1.3 Date of Observation

12/12/2022

2.1.4 Test Method

N/A

2.1.5 Environmental Conditions

N/A

2.1.6 Test Results

The EUT utilizes the PCB antenna which is internal to the enclosure and affixed to the PCB, therefore satisfying the requirements of Section 15.203.

2.2 Power Line Conducted Emissions

2.2.1 Specification Reference

FCC Section: 15.207
ISED Canada: RSS-Gen 8.8

2.2.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state “1”, as noted in §1.6.

2.2.3 Date of Test

1/18/2023

2.2.4 Test Method

ANSI C63.10 section 6 was the guiding documents for this evaluation. Conducted emissions were performed from 150kHz to 30MHz with the spectrum analyzer’s resolution bandwidth set to 9kHz and the video bandwidth set to 30kHz. The calculation for the conducted emissions is as follows:

Corrected Reading = Analyzer Reading + LISN Loss + Cable Loss
Margin = Corrected Reading - Applicable Limit

2.2.5 Environmental Conditions

The EUT was evaluated within the temperature, humidity and pressure range of the EUT as specified by the standard. The laboratory shall have an ambient temperature range of 15°C to 35°C, relative humidity range of 30% to 60% and atmospheric pressure range of 86 kPa to 106 kPa.

Ambient Temperature	24 °C
Relative Humidity	43 %
Atmospheric Pressure	982.1 mbar

2.2.6 Test Results

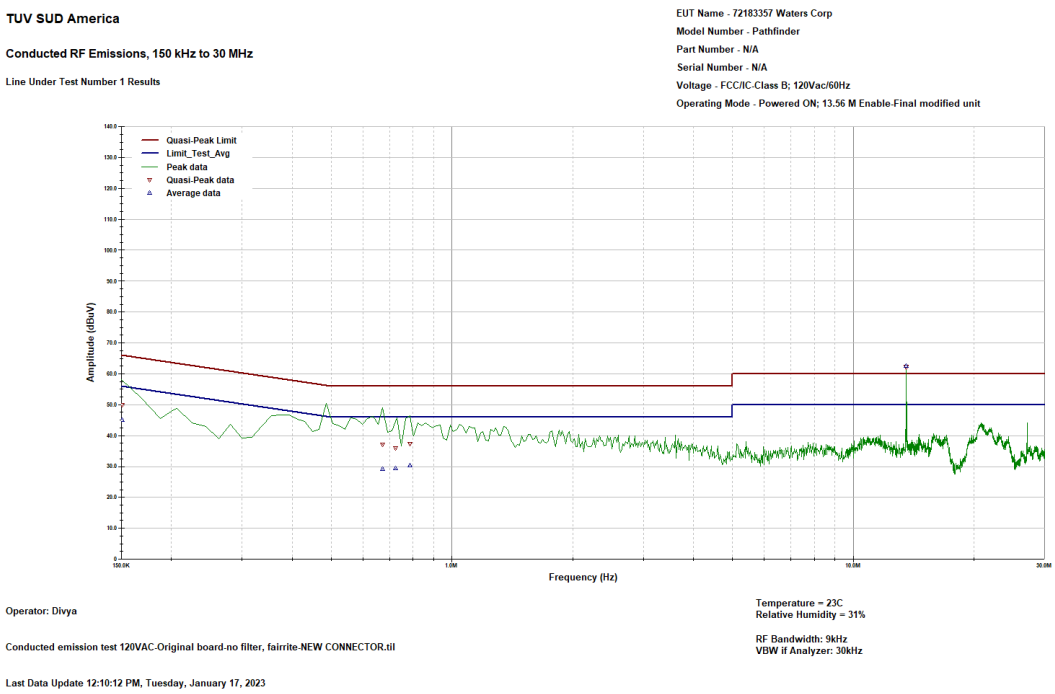

Figure 2.2.6-1 – Graphical Results – AC Mains L1 Plot – 13.56MHz enable with Antenna connected

Note: emission above limit line is 13.56 MHz fundamental frequency.

Table 2.2.6-1 – Conducted Emissions Results on the AC Power Port (L1)

Frequency (MHz)	Avg Limit	Avg Level Corr	Avg Level	Corr Fact.	Avg Margin	Result
0.15	56	45.1	35.4	9.682	-10.9	PASS
0.67	46	29.2	19.6	9.66	-16.8	PASS
0.72	46	29.4	19.7	9.663	-16.6	PASS
0.79	46	30.2	20.6	9.667	-15.8	PASS

Frequency (MHz)	QP Limit	QP Level Corr	QP Level	Corr Fact.	QP Margin	Result
0.15	66	49.9	40.3	9.682	-16	PASS
0.67	56	37	27.4	9.66	-19	PASS
0.72	56	35.8	26.2	9.663	-20.2	PASS
0.79	56	37.2	27.6	9.667	-18.8	PASS

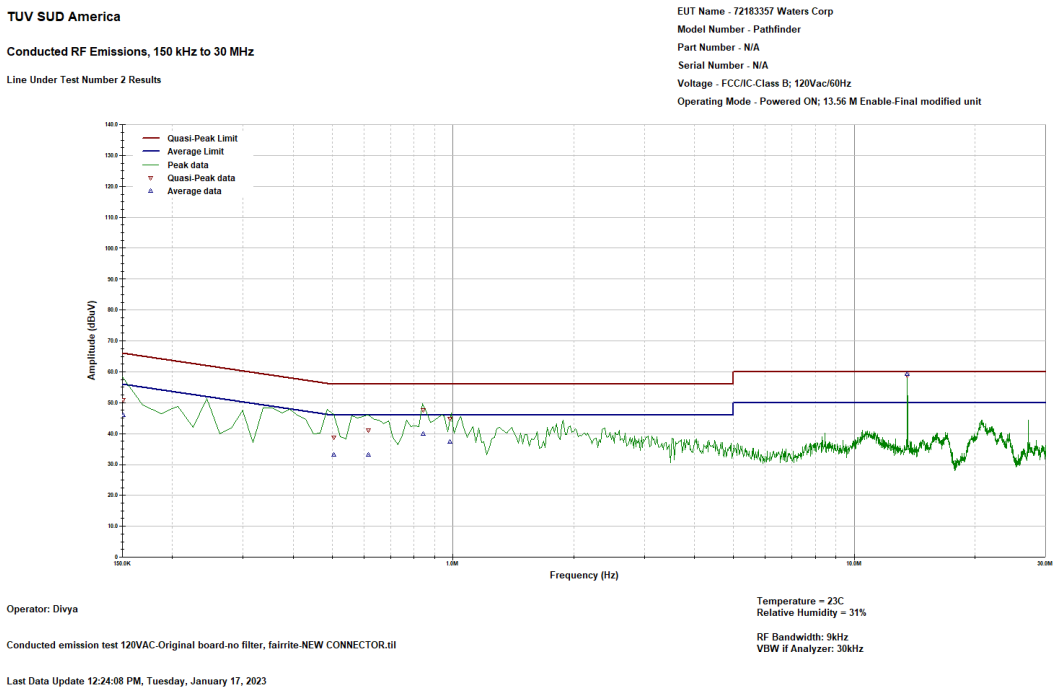

Figure 2.2.6-2 – Graphical Results – AC Mains N Plot – 13.56MHz enable with Antenna connected

Note: emission above limit line is 13.56 MHz fundamental frequency.

Table 2.2.6-2 – Conducted Emissions Results on the AC Power Port (N)

Frequency (MHz)	Avg Limit	Avg Level Corr	Avg Level	Corr Fact.	Avg Margin	Result
0.15	56	45.9	36.2	9.675	-10.1	PASS
0.5	46	33.1	23.5	9.63	-12.9	PASS
0.62	46	33.2	23.6	9.637	-12.8	PASS
0.84	46	39.9	30.3	9.651	-6.1	PASS
0.98	46	37.2	27.5	9.659	-8.8	PASS

Frequency (MHz)	QP Limit	QP Level Corr	QP Level	Corr Fact.	QP Margin	Result
0.15	66	50.8	41.2	9.675	-15.2	PASS
0.5	56	38.8	29.2	9.63	-17.2	PASS
0.62	56	40.9	31.3	9.637	-15.1	PASS
0.84	56	47.5	37.8	9.651	-8.5	PASS
0.98	56	44.8	35.2	9.659	-11.2	PASS

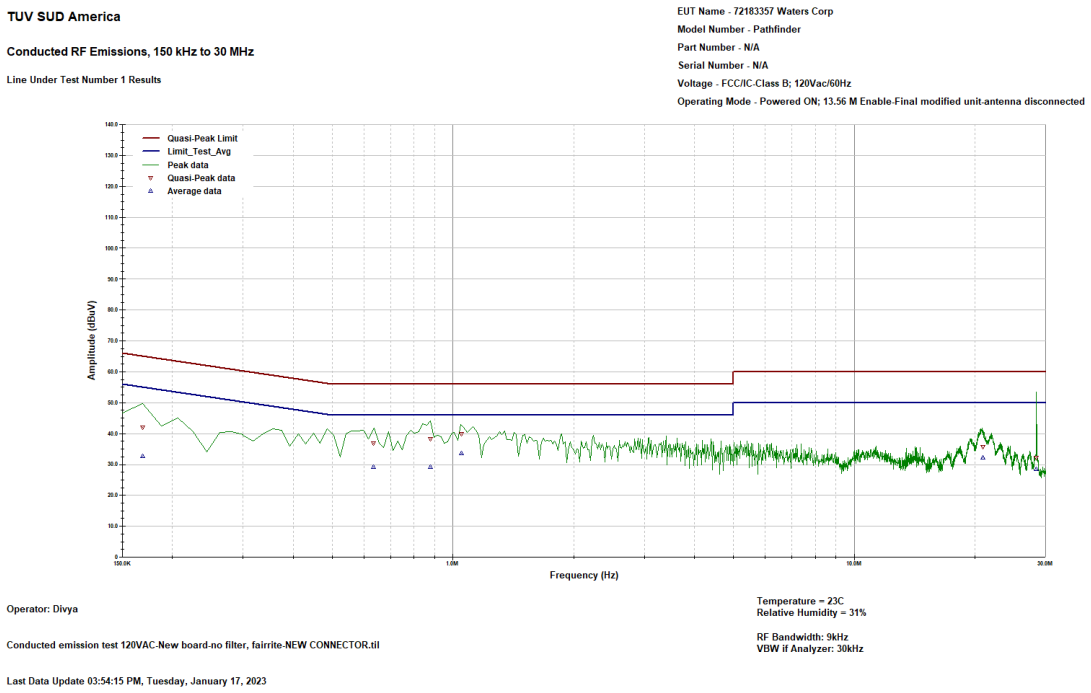

Figure 2.2.6-3 – Graphical Results – AC Mains L1 Plot – 13.56MHz enable with Antenna terminated with a matching impedance.

Table 2.2.6-3 – Conducted Emissions Results on the AC Power Port (L1)

Frequency (MHz)	Avg Limit	Avg Level Corr	Avg Level	Corr Fact.	Avg Margin	Result
0.17	55.5	32.6	23	9.68	-22.9	PASS
0.63	46	29.1	19.5	9.658	-16.9	PASS
0.88	46	29.3	19.6	9.673	-16.7	PASS
1.05	46	33.5	23.8	9.683	-12.5	PASS
20.93	50	32.2	22.2	9.981	-17.8	PASS
28.42	50	28.5	18.4	10.08	-21.5	PASS

Frequency (MHz)	QP Limit	QP Level Corr	QP Level	Corr Fact.	QP Margin	Result
0.17	65.5	41.9	32.2	9.68	-23.6	PASS
0.63	56	36.9	27.2	9.658	-19.1	PASS
0.88	56	38.3	28.6	9.673	-17.7	PASS
1.05	56	40	30.3	9.683	-16	PASS
20.93	60	35.8	25.8	9.981	-24.2	PASS
28.42	60	32.1	22	10.08	-27.9	PASS

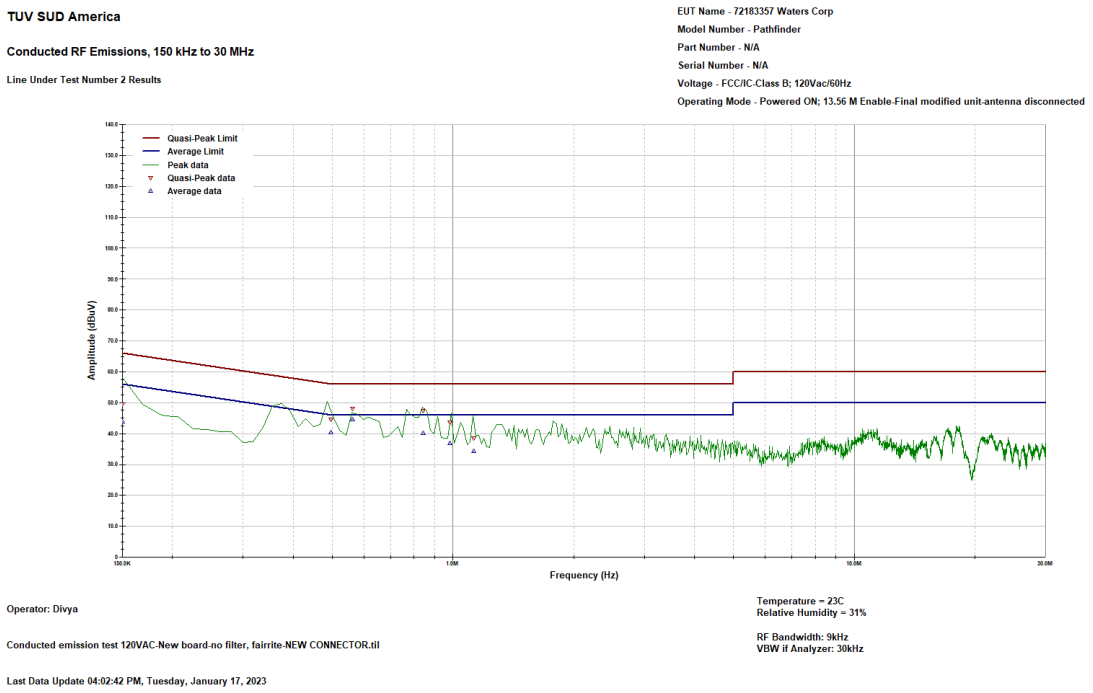

Figure 2.2.6-4 – Graphical Results – AC Mains N Plot – 13.56MHz enable with Antenna terminated with a matching impedance.

Table 2.2.6-4 – Conducted Emissions Results on the AC Power Port (N)

Frequency (MHz)	Avg Limit	Avg Level Corr	Avg Level	Corr Fact.	Avg Margin	Result
0.15	56	43.8	34.1	9.675	-12.2	PASS
0.5	46.1	40.3	30.6	9.631	-5.8	PASS
0.56	46	44.6	35	9.634	-1.4	PASS
0.84	46	40	30.4	9.651	-6	PASS
0.98	46	37	27.3	9.659	-9	PASS
1.13	46	34.2	24.6	9.675	-11.8	PASS

Frequency (MHz)	QP Limit	QP Level Corr	QP Level	Corr Fact.	QP Margin	Result
0.15	66	49.4	39.7	9.675	-16.6	PASS
0.5	56.1	44.6	35	9.631	-11.5	PASS
0.56	56	48	38.3	9.634	-8	PASS
0.84	56	47.4	37.8	9.651	-8.6	PASS
0.98	56	43.7	34	9.659	-12.3	PASS
1.13	56	38.4	28.8	9.675	-17.6	PASS

2.3 Frequency Stability

2.3.1 Specification Reference

FCC Sections: 15.225(e)
ISED Canada RSS -210 B.6(b)

2.3.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state “1”, as noted in §1.6.

2.3.3 Date of Test

12/27/2022

2.3.4 Test Method

EUT was transmitting continuous modulate signal during the test. Measurement was done using the spectrum analyzer’s frequency counter function to measure the frequency variation of the EUT’s RFID system. The RBW was set to 10 kHz for better resolution.

The temperature was varied from 4°C to +40°C in °C increments with voltage variation of 85% and 115% nominal input voltage @ 20°C.

2.3.5 Environmental Conditions

The EUT was evaluated within the temperature, humidity and pressure range of the EUT as specified by the standard. The laboratory shall have an ambient temperature range of 15°C to 35°C, relative humidity range of 30% to 60% and atmospheric pressure range of 86 kPa to 106 kPa.

Ambient Temperature	24 °C
Relative Humidity	43 %
Atmospheric Pressure	982.1 mbar

2.3.6 Test Results

Test Summary: EUT was set to transmit mode.

Test Results: Pass

See data below for detailed results.

Table 2.3.6-1 Frequency Stability data

Nominal Voltage (Vdc)		120V	Nominal Frequency (MHz)	13.56	
Voltage (VDC)	**Temperature (°C)**	**Measured Frequency (MHz)**		**Frequency Deviation (%)**	**Frequency Error (ppm)**
120	-20	13.56045		0.00332	33.19
	-10	13.56045		0.00332	33.19
	0	13.56049		0.00361	36.14
	4	13.56049		0.00361	36.14
	10	13.5605		0.00369	36.87
	20	13.5605		0.00369	36.87
	30	13.56049		0.00361	36.14
	40	13.56046		0.00339	33.92
	50	13.56044		0.00324	32.45
102	20	13.560462		0.00341	34.07
138	20	13.560622		0.00459	45.87

FCC 47 CFR Part 15, Limit Clause 15.225 (e)

The frequency tolerance of the carrier signal shall be maintained within +/- 0.01 % of the operating frequency.

Industry Canada RSS-210, Limit Clause B.6

Carrier frequency stability shall be maintained to +/-0.01% (+/-100ppm)

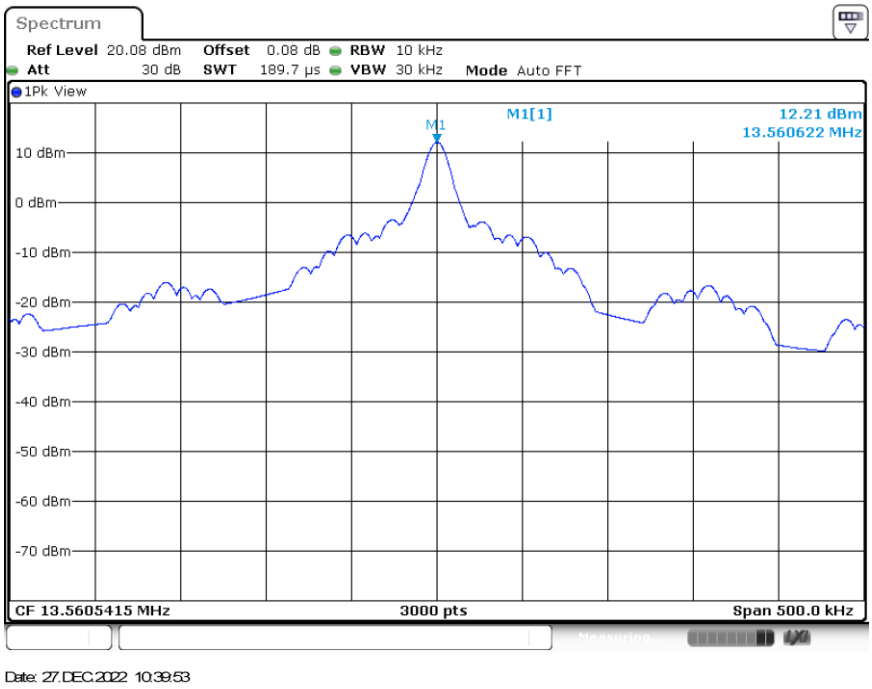

Figure 2.3.6-1 Reference plot at Nominal Voltage @ 20 °C

2.4 20 dB / 99% Bandwidth

2.4.1 Specification Reference

FCC Sections: 15.215(c)
ISED Canada RSS -Gen 6.7

2.4.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state “1”, as noted in §1.6.

2.4.3 Date of Test

12/27/2022

2.4.4 Test Method

The RF output port of the EUT was directly connected to the input of the spectrum analyzer with suitable attenuation. The span of the spectrum analyzer display was set between two times and five times the occupied bandwidth (OBW) of the emission. The RBW of the spectrum analyzer was set to approximately 1 % to 5 % of the OBW. The trace was set to max hold with a peak detector active. The Delta and ndB down functions of the analyzer were utilized to determine the 20 dB bandwidth of the emission.

The occupied bandwidth measurement function of the spectrum analyzer was used to measure the 99% bandwidth. The span of the analyzer was set to capture all products of the modulation process, including the emission sidebands. The resolution bandwidth was set to 1% to 5% of the occupied bandwidth. The video bandwidth was set to 3 times the resolution bandwidth. A peak detector was used.

2.4.5 Environmental Conditions

The EUT was evaluated within the temperature, humidity and pressure range of the EUT as specified by the standard. The laboratory shall have an ambient temperature range of 15°C to 35°C, relative humidity range of 30% to 60% and atmospheric pressure range of 86 kPa to 106 kPa.

Ambient Temperature	24 °C
Relative Humidity	43 %
Atmospheric Pressure	982.1 mbar

2.4.6 Test Results

Test Summary: EUT was set to transmit mode.

Test Results: Pass

See data below for detailed results.

Table 2.4.6-1 20 dB / 99% Bandwidth

Frequency [MHz]	20dB Bandwidth (Hz)	99% Bandwidth (kHz)
13.56	246.5	1.398

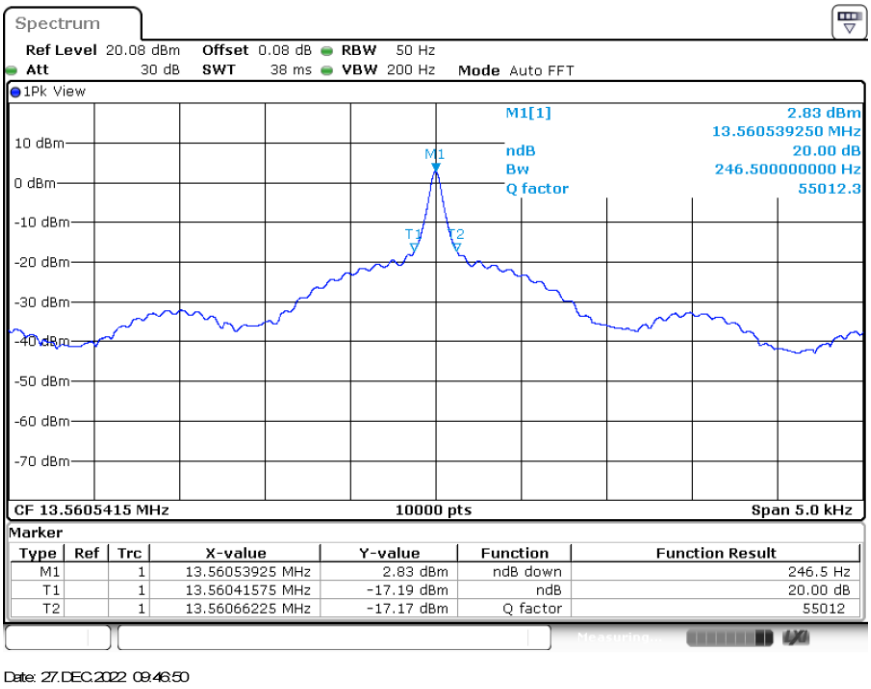

Figure 2.4.6-1: 20 dB Bandwidth

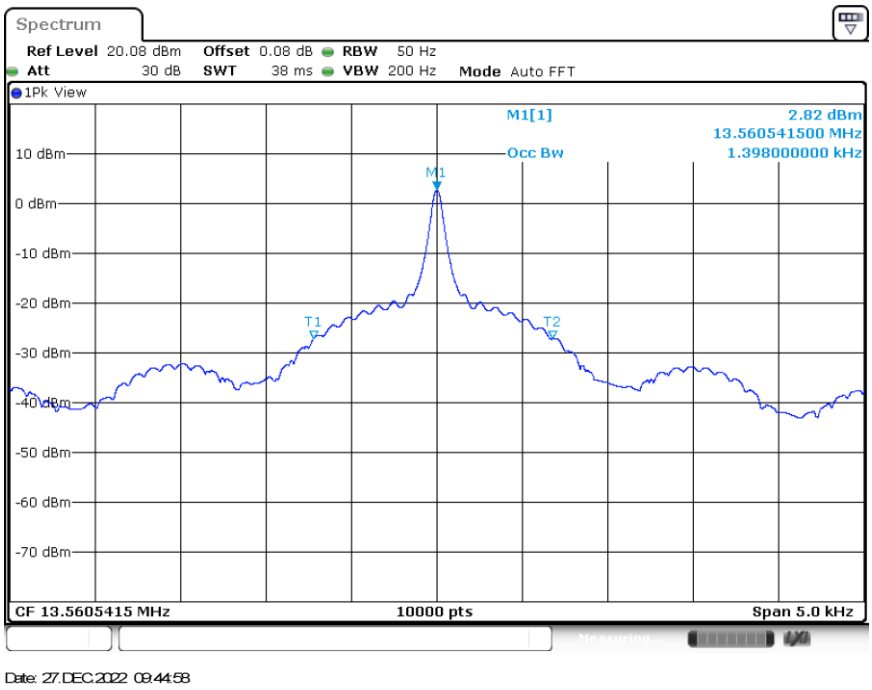

Figure 2.4.6-2: 99% Bandwidth

2.5 Emission Mask

2.5.1 Specification Reference

FCC Sections: 15.225(a)(b)(c).
ISED Canada RSS – 210 B.6(a)(i)(ii)(iii)

2.5.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state “1”, as noted in §1.6.

2.5.3 Date of Test

01/18/2023

2.5.4 Test Method

Radiated emissions tests were made over the frequency range of 13.110 MHz to 14.010 MHz. Each emission found to be in emission bands as defined by section 15.225, was compared to the radiated emission limits as defined in Section 15.225(a)(b)(c).

The EUT was rotated through 360° and the receive antenna height was varied from 1m to 4m so that the maximum radiated emissions level would be detected. For frequencies between 150 kHz and 30MHz, quasi-peak measurements were made using a resolution bandwidth RBW of 10 kHz and a video bandwidth VBW of 30 kHz.

2.5.5 Environmental Conditions

The EUT was evaluated within the temperature, humidity and pressure range of the EUT as specified by the standard. The laboratory shall have an ambient temperature range of 15°C to 35°C, relative humidity range of 30% to 60% and atmospheric pressure range of 86 kPa to 106 kPa.

Ambient Temperature	24 °C
Relative Humidity	43 %
Atmospheric Pressure	982.1 mbar

2.5.6 Test Results

Test Summary: EUT was set to transmit mode.

Test Results: Pass

Table 2.5.6-1: Emission mask Data

Frequency	QP Value	QP Limit	QP Margin	QP Limit Results
MHz	dBµV/m @ 3 m	dBµV/m @ 3 m	dB	Pass/Fail
13.34	27.382	80.5	-53.12	PASS
13.525	32.86	90.5	-57.64	PASS
13.561	62.252	124	-61.75	PASS
13.593	33.29	90.5	-57.21	PASS
13.792	28.489	80.5	-52.01	PASS

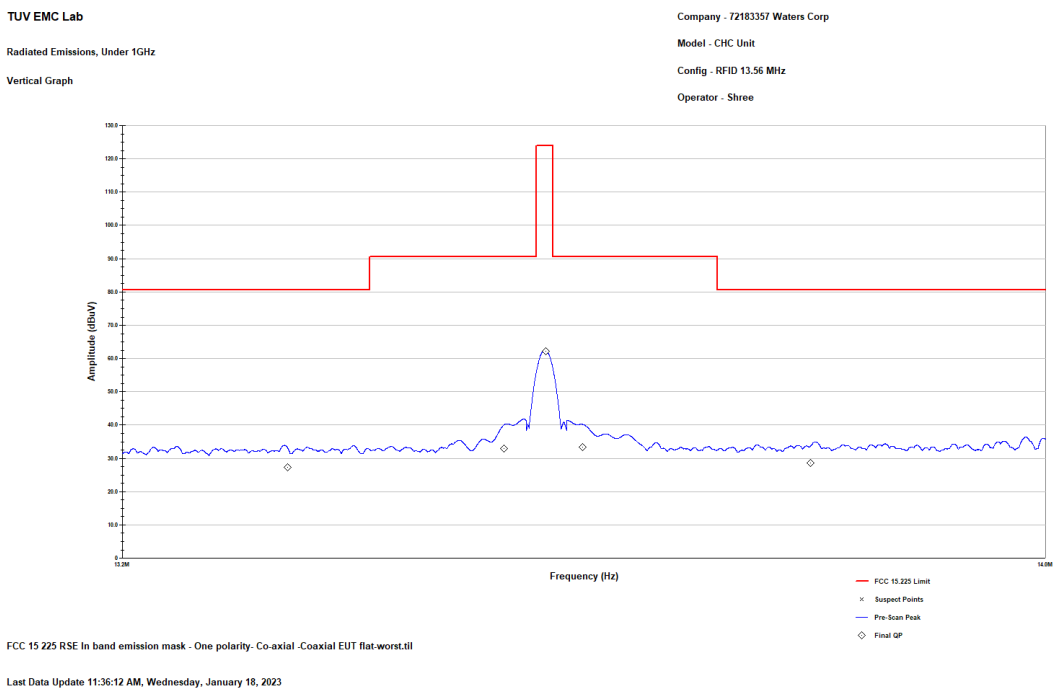

Figure 2.5.6-1: In-band emission mask

Sample Calculation (Limit):

Limit @ 13.553- 13.567 MHz: 15848 µV/m @ 30 meters

20 log (15848 µV/m) = 84 dBµV/m @ 30 meters

40log(30m/3m) = 40, 40dB/decade extrapolation rule

Final calculated limit @ 3 m 84 dBµV/m + 40 dB = 124 dBµV/m @ 3 m

2.6 Radiated Spurious Emissions

2.6.1 Specification Reference

FCC Sections: 15.225, 15.209.
ISED Canada RSS – Gen 8.9/8.10

2.6.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state “1”, as noted in §1.6.

2.6.3 Date of Test

12/07/2022 to 01/18/2023

2.6.4 Test Method

Radiated emissions tests were made over the frequency range of 9 kHz to 1000 MHz, 10 times the fundamental frequency of 13.56 MHz. Each emission found to be in a restricted band as defined by section 15.225, was compared to the radiated emission limits as defined in Section 15.209.

The EUT was rotated through 360° and the receive antenna height was varied from 1m to 4m so that the maximum radiated emissions level would be detected. For frequencies below 150 kHz, quasi-peak measurements were made using a resolution bandwidth RBW of 300 Hz and a video bandwidth VBW of 1 kHz and frequencies between 150 kHz and 30MHz, quasi-peak measurements were made using a resolution bandwidth RBW of 10 kHz and a video bandwidth VBW of 30 kHz. For frequencies between 30 MHz and 1000 MHz, quasi-peak measurements were made using a resolution bandwidth RBW of 100 kHz and a video bandwidth VBW of 300 kHz.

2.6.5 Environmental Conditions

The EUT was evaluated within the temperature, humidity and pressure range of the EUT as specified by the standard. The laboratory shall have an ambient temperature range of 15°C to 35°C, relative humidity range of 30% to 60% and atmospheric pressure range of 86 kPa to 106 kPa.

Ambient Temperature	24 °C
Relative Humidity	43 %
Atmospheric Pressure	982.1 mbar

2.6.6 Test Results

Test Summary: EUT was set to transmit mode.

Test Results: Pass

See data below for detailed results.

Table 2.6.6-1: Radiated Spurious Emissions Tabulated Data

Frequency	QP/Avg Value	QP/Avg Limit	QP/Avg Margin	Polarity	QP/Avg Limit Results
MHz	dBµV/m	dBµV/m	dB	H/V	Pass/Fail
144.487	35.515	43.5	-7.98	H	PASS
149.845	39.233	43.5	-4.27	H	PASS
279.536	35.509	46	-10.49	H	PASS
325.437	41.017	46	-4.98	H	PASS
352.574	41.038	46	-4.96	H	PASS
569.538	39.892	46	-6.11	H	PASS
144.487	35.515	43.5	-7.98	H	PASS
55.22	34.711	40	-5.29	V	PASS
210.666	34.11	43.5	-9.39	V	PASS
276.965	37.039	46	-8.96	V	PASS
283.633	35.238	46	-10.76	V	PASS
289.453	34.701	46	-11.3	V	PASS
303.082	29.41	46	-16.59	V	PASS

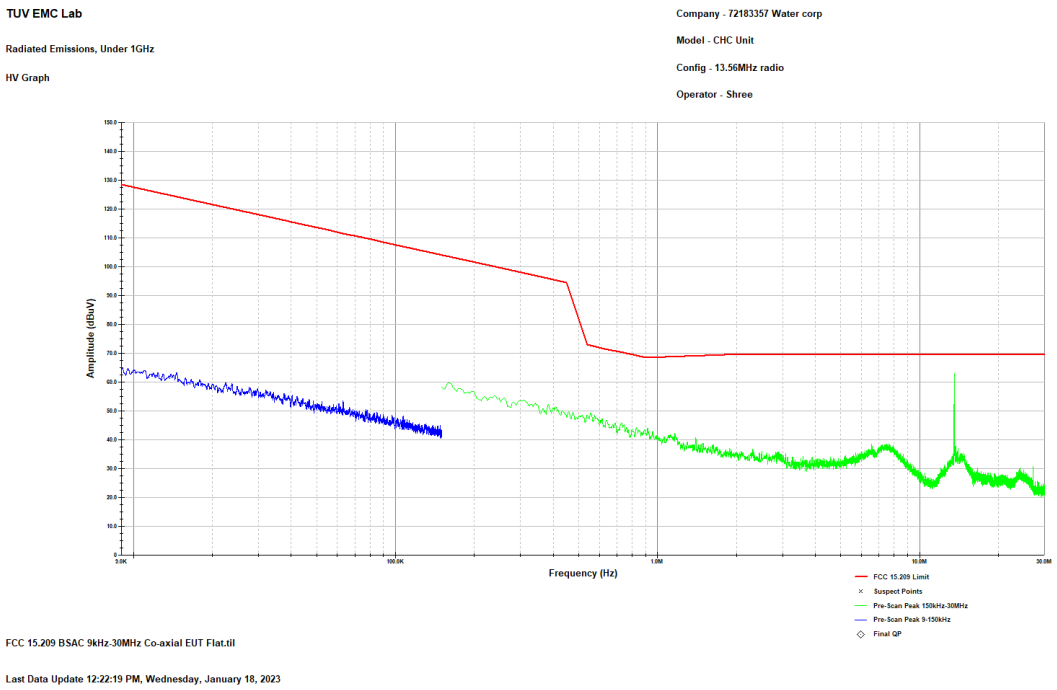

Figure 2.6.6-1: Radiated Spurious Emissions – 9 kHz – 30 MHz

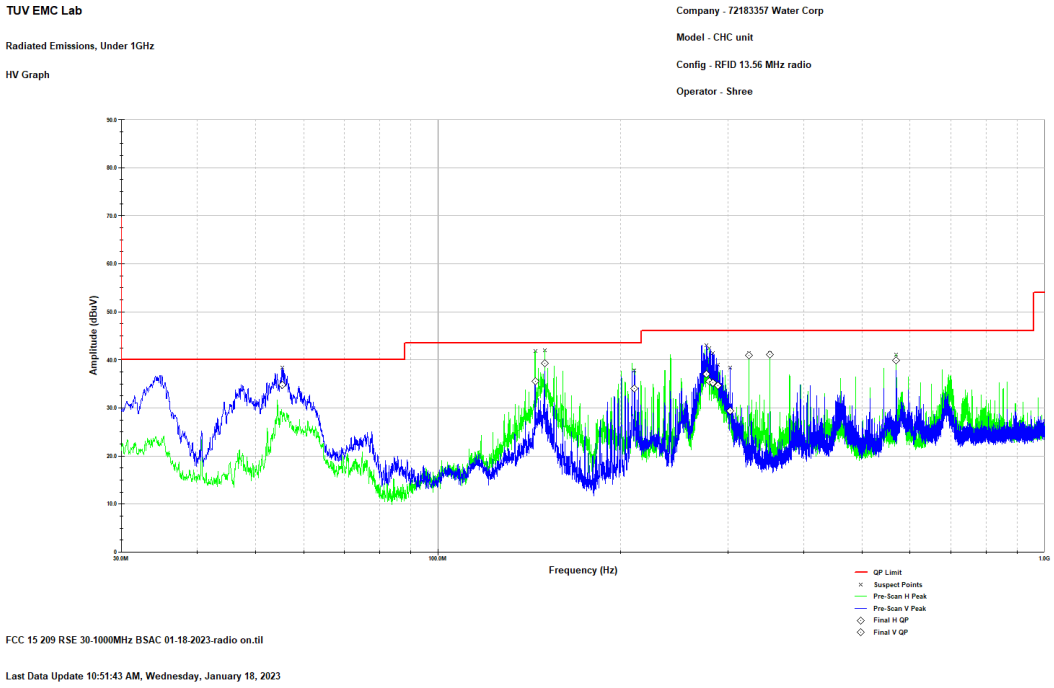

Figure 2.6.6-2: Radiated Spurious Emissions – 30 MHz – 1 GHz

2.7 Test Equipment Used

Table 2.7-1 –Equipment List

Asset ID	Manufacturer	Model	Equipment Type	Serial Number	Last Calibration Date	Calibration Due Date
628	EMCO	6502	Loop antenna	9407-2877	6/8/2021	6/8/2023
853	Teseq	CBL6112D	BiLog Antenna	51616	7/15/2021	7/15/2023
889	Com Power	PAM 103	Pre-amplifier	18020215	9/27/2022	9/27/2023
882	Rohde & Schwarz	ESW44	ESW44 EMI TEST RECEIVER	101961	7/14/2022	7/14/2023
22	Teledyne Storm Microwave	90-195-456	BSAC Cable	N/A	10/7/2022	10/7/2023
20	Teledyne Storm Microwave	R-90-195-036	BSAC Cable	N/A	7/12/2022	7/12/2023
21	Teledyne Storm Microwave	R-90-195-072	BSAC Cable	N/A	7/12/2022	7/12/2023
827	Rohde & Schwarz	RF Cable set	TS8997 Rack cable set	N/A	12/20/2022	12/20/2023
622	Rohde & Schwarz	FSV40 (v3.40)	FSV Signal Analyzer 10Hz to 40GHz	101338	10/05/2022	10/05/2023
881	Fluke Corporation	52 II	Thermocouple Thermometer	49390196WS	8/24/2022	8/24/2023
694	Thermotron	S-1.2C	Temperature chamber	19753	NCR	NCR

N/A – Not Applicable

3 Diagram of Test Set-ups

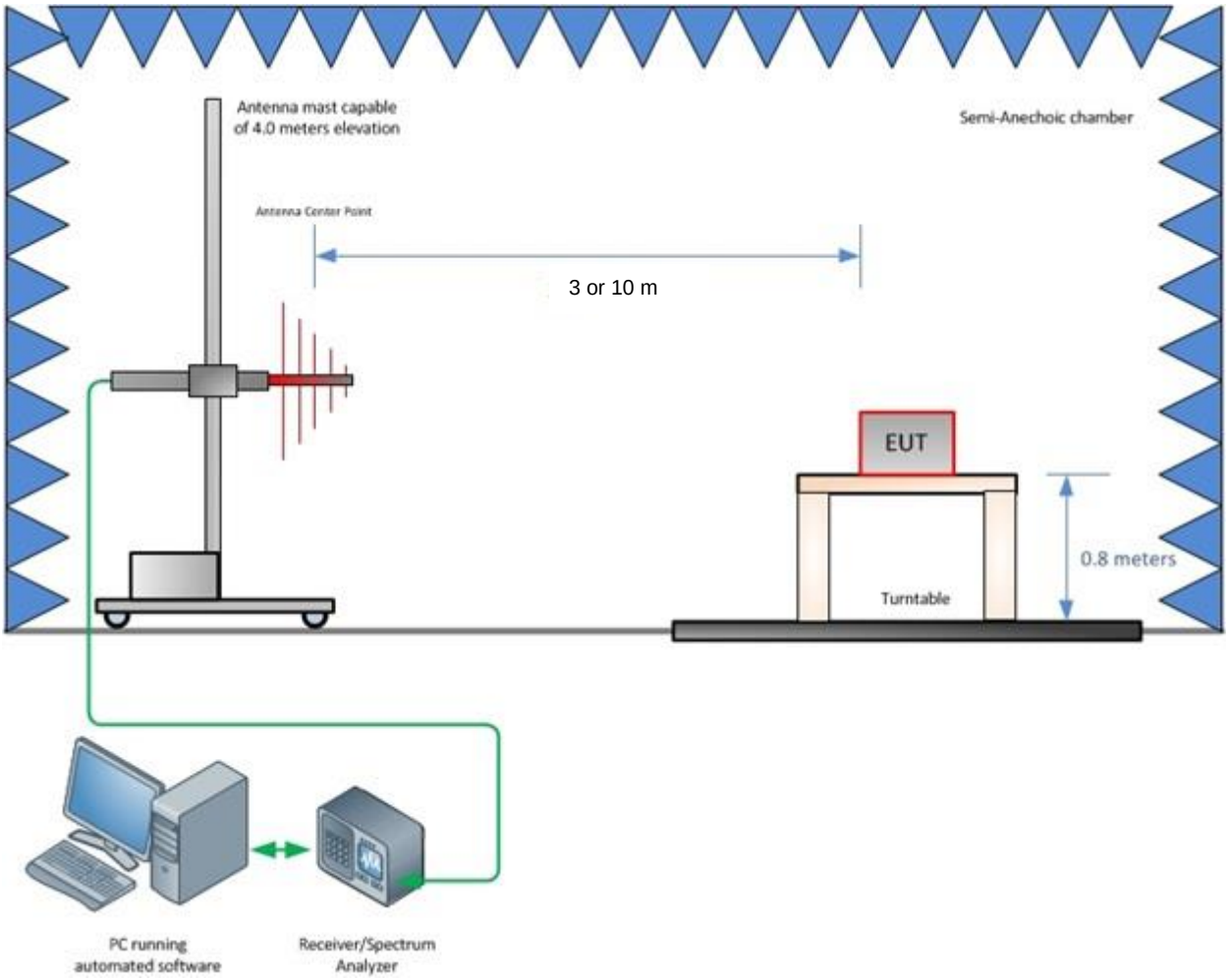

Figure 3-1 – Radiated Emissions Test Setup up to 1 GHz

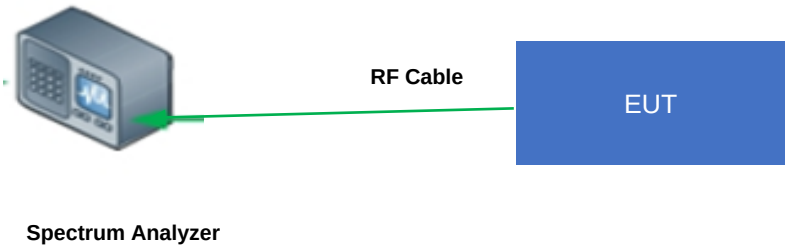

Figure 3-2 – Conducted Test Setup: Antenna Port measurement

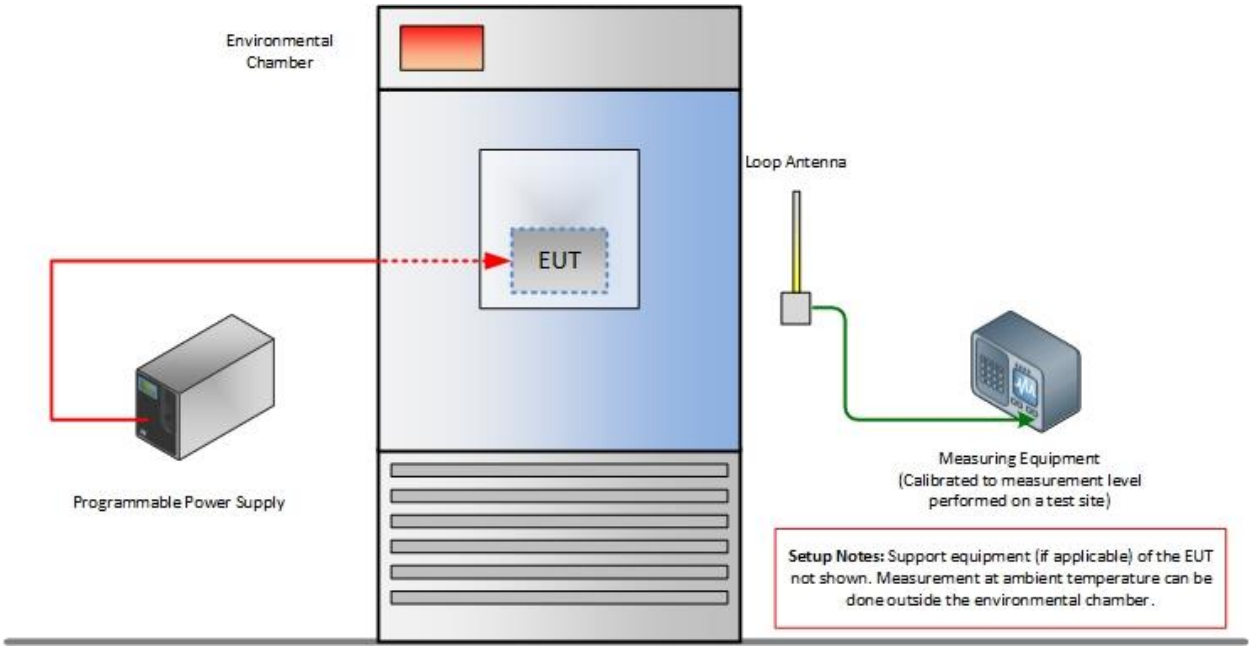

Figure 3-3 – Frequency Stability < 30 MHz

4 Accreditation, Disclaimers and Copyright

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STATEMENT OF MEASUREMENT UNCERTAINTY – Emissions

The expanded laboratory measurement uncertainty figures (U_{Lab}) provided below correspond to an expansion factor (coverage factor) k = 1.96 which provide confidence levels of 95%.

Table 4-1: Estimation of Measurement Uncertainty

Parameter	U_{lab}
Radiated Emissions ≤ 1 GHz	± 5.814 dB
Radiated Emissions > 1 GHz	± 4.318 dB
Temperature	± 0.860 °C
Radio Frequency	± 2.832 x 10^{-8}
AC Power Line Conducted Emissions	± 3.360 dB

TEST EQUIPMENT

All measurement instrumentation is traceable to the National Institute of Standards and Technology and is calibrated to meet test method standard requirements and/or manufacturer's specifications